Report of Dr. E. J. BUTLER, M.B., F.L.S., Cryptogamic Botanist to the Government of India, on the palmyra disease in the Godavari delta.

1. In 1904 the outbreak of a serious disease in the palmyra palms of the Godavari delta was reported. In 1905 information was received that cocoanut palms were also attacked, and the danger which might arise in the rich palm plantations of Southern India was at once apparent. The following account is the result of a visit to the delta for the purpose of investigating the disease in August 1905.

2. The disease is said to have been noticed as far back as 1897. It has, however, only attracted attention by its extension within the past two or three years. It is said to have been seen first in Addunkivarilanka in the north channel of the Godavari. From here it spread into the Amalpuram Taluk on the southern bank and to the Ramachendrapuram Taluk on the northern bank. It is now found in an area on both sides of the northern channel, occupying the whole of the Amalpuram Taluk, except the swampy district towards the sea, while on the Ramachendrapuram side it has reached Anaparti about 12 miles from the river. Along the banks it extends about thirty miles on both sides from the vicinity of the French Settlement of Yanam near the village of Kolanka to Madiki and Lolla. As in most other cases of infectious epidemics it does not occupy an absolutely continuous area. Some villages have escaped although surrounded by diseased localities, and in some directions extension has progressed much more rapidly than in others. Thus the disease has been known at Kolanka for six or eight years and a mile or two to the east, the palms are dead in great numbers, yet another mile further on not a single case was seen in thousands of palms visible from the canal.

3. It may, however, be said in a general way that in a circle from the centre at Addunkivarilanka where it is said to have started, with a radius of fourteen miles, most of the villages are affected. In the portion of Cocanada Taluk towards the river some twenty-five villages have also reported the presence of the disease to the Tahsildar.

4. The sharp limitation of the affected locality, which is evident, for instance, between Kolanka and Yanam, joined to the slow extension though an almost continuous area indicates an infection by some germ incapable of rapid transmission. It is hence opposed to the view which was believed by some of the local officials that insects such as cockchafers which are common enough in the diseased tree can be other than remotely concerned with it. It is also opposed in a general way to the idea that any fungus possessing small or light spores formed on the surface of the affected parts can be the cause. As will be seen, the organism to which the disease is attributed is just such a one as would account for the somewhat peculiar type of extension.

5. The extent of the damage can only be estimated very roughly. Along the Amalpur East Bank Canal seventy-six per cent of one hundred and thirty consecutively numbered palms were dead. This was in a very bad place. In a similar line near Kolanka thirty per cent were dead. Elsewhere every proportion down to few or no dead trees was seen. Possibly about ten per cent of the palmyra palms of the above mentioned area have been killed. The trees are said to be worth about two rupees per annum and the loss already sustained must run into lakhs.

6. Possibly, the most serious feature of the position is the fact that cocoanut palms are undoubtedly subject to infection. In Ramachendrapuram Taluk a few cases were seen, but in Amalpur they are numerous, though the cocoanut palm is never, in any of the localities visited, so frequently attacked as the palmyra. This is perhaps due to its harder tissues which oppose a barrier to infection. In Modenurru some two hundred dead trees were seen, but elsewhere only a dozen or two. The danger that the disease may increase in virulence in regard to cocoanut palms, if permitted, to rage unchecked, is one that need hardly be emphasised. A few betel palms (areca catechu) were found suffering from apparently the same disease, but the cases were too far advanced for satisfactory examination.

7. Little or nothing is known of the diseases to which palms are liable. I have seen three distinct palm affections within the past two years. In Mysore the betel palms have been killed in large numbers by a disease called locally *Koleroga* probably caused by a fungus of the genus *phytophthora*, the same genus to which the fungus which causes potato disease belongs, and a near ally of that to which I attribute the present disease. In Sylhet, recently, I found enormous numbers of the same palm dying from a root destroying fungus which appears to extend through the soil. A somewhat similar or perhaps identical disease was described by Sir George Watt from Eastern Bengal in Agricultural Ledger No. 8 of 1901. In the West Indies and neighbouring localities a disease of the cocoanut palm known as "bud rot" is causing considerable anxiety at the present time. Jamaica, Trinidad, Cuba, British Honduras and British Guiana are affected, and there appears to be no doubt that the disease is spreading. The part involved is the green top or "cabbage" of the palm which may be entirely destroyed while the stem and roots are still healthy. In this case the rot is said to originate in the heart of the bud and to extend outwards, which is the reverse of the case in the Godavari palm disease. The cause is unknown, but it is suspected to be a rotting bacillus and as the matter is engaging the attention of the Agricultural Department of the United States and of the British West Indies, some light may be expected on what is evidently a rather mysterious affection in the near future. Dr. E. F. Smith, United States Department of Agriculture, who

studied it in Cuba in 1904, says in his report that if it continues to spread as it has done during the past ten years, it will inevitably destroy the cocoanut industry of the island and that too within the next ten or fifteen years. This case is referred to as it is evident that the cocoanut palm is liable to epidemic disease and disease of a serious nature and the possibility of a similar state of affairs arising in the immensely valuable cocoanut districts of the Madras littoral by the extension of the disease from the Godavari delta is not one to be neglected. In all these diseases the ultimate effect is the same, for in all the green top eventually withers and falls off, leaving the stem standing as a bare pole.

8. The symptoms of the palmyra disease are such that it can be recognised fairly easily. Most of the proprietors who were questioned were able to point out even the early cases, their statements being checked by cutting down a number of the trees pointed out. The earliest sign is an alteration in colour of one of the leaves, usually one of those recently expanded, towards the centre of the head. This turns white and soon afterwards commences to wither. Other leaves are attacked in succession, the heart of the bud is reached, and the whole top withers and falls off, the last stage often being reached only after a considerable time. In cocoanut palms the same general course is followed, but here if the nuts have been formed before the attack becomes severe they are often dropped prematurely. No new nuts are formed once the characteristic symptoms show. The following account is taken from the examination of diseased palmyra palms, but the description applies closely to the disease in cocoanut palms and the same fungus was found associated with it in both cases.

9. The whole of the stem and root system is perfectly healthy up to a late stage in the disease. The latter was excavated and examined with particular care in a number of cases owing to the previous experience with the Sylhet Betel-nut palm disease. It, however, was early evident that the seat of the disease is the crown of the tree. Here the expanded parts of the leaves are unaltered and apparently healthy until withering sets in. In the leaf-sheaths, however, which are such a marked feature of the palm bud, the case is otherwise. These surrounded the apex of the pole forming twenty or thirty tube-like layers closely applied one over the other, so as to form a funnel at the bottom of which is the growing point of the tree. On examination irregular sunken-in spots were found in greater or less number on the sheaths of all diseased trees. In the earlier stages and particularly in the inner layers where young spots are numerous, they are white, later on becoming brown but always sunken and usually with somewhat raised edges. They may be traced in from the outer sheaths, sometimes passing through every succeeding layer until the heart of the bud is reached. These necrosed spots often spread more rapidly in the inner layers and new lines of extension may arise from large affected areas within the bud which pass outwards to give rise to new spots on the outer leaves. This gives a false appearance of extension from within outwards, but in all cases where the course could be accurately followed, the first spots appeared on the outer sheaths and as a general rule, the progress is inwards until the tender centre of the shoot is eventually reached. The earlier spots are dry and either show no signs of a foreign organism on their surface or are covered with a whitish felt of fungus growth. Very soon a wet rot follows, which extends with great rapidity in the delicate central tissues of the bud and the whole of the heart becomes a foul-smelling mass of putrefaction, in which everything is involved and the original agent is lost sight of. It is at this stage that a cockchafer grub which has been often noticed in diseased trees and was considered by some of the local cultivators to cause the disease makes its appearance possibly attracted by the smell. The mere fact that it is absent in many deceased trees is sufficient to exclude it from an active part in the epidemic. No one species of insect was found to be invariably present though naturally fly larvæ and other insects abound in the later stages of putrefaction and even scorpions were found in considerable numbers in some cases.

10. It is only by examining young spreading spots at a period before the wet rot sets in that there is any prospect of ascertaining the cause of the disease. At a later stage the tissues are so broken down, and such a multitude of organisms appear in the fermenting mass, that it would prove a task of great difficulty to separate out the different species for purposes of study. At this period too the organism originally present in the spots had disappeared with the possible exception of its resting spores and the labour of examining cases far advanced in the disease is just so much time wasted.

11. In young spreading spots large unseptate filaments of a fungus are found extending through the tissues in the shrunken area. These are entirely confined to the parenchymatous tissues and do not penetrate the fibro-vascular bundles. Many of the young spots are covered with a thick white felt of these filaments, which may be traced into the interior in direct continuation of those within the tissues. They are fairly characteristic being irregularly branched, swollen, without anastomoses or junctions and entirely unseptate. On the surface of the spots this mycelium produces its spores which are those distinctive of the genus *Pythium*. The filaments within the tissues lie between the cells, not inside them, but send short processes through the cell wall by means of which the cell contents are taken up as food by the fungus. No other *Pythium* is known which obtains its food in this manner and as those other classes of fungi which do so are all strict parasites, it is possible that this species is only capable of feeding on living matter. The presence of this peculiarity is almost conclusive proof that the fungus is a vigorous parasite and strongly supports the view that it is the cause of the disease.

12. A number of the *Pythiaceae* are parasitic though all, so far as is known, can grow also on dead matter. In all the parasitic species which have been studied, the effects are similar to the present case, except in one particular. The hyphae of other species destroy the cell contents directly by entering them, no action being produced except in the vicinity of the growing mycelium, but each cell being killed as the filaments reach or come near it. After the tissues are dead the fungus continues to grow and forms its reproductive bodies in the interior or on the surface of the affected area. In the present case, many of the cells are not entered by the fungus, and those which are, only have short processes pushed into them, yet the cell destruction in the affected areas is complete; the only explanation must be that the fungus can destroy cell life at some little distance beyond its own body. Many similar cases are known and all such as have been investigated are found to act by means of destructive ferments given off from the fungus mycelium.

13. The full description of the species will be published elsewhere. A brief account is, however, necessary to enable its probable life history to be understood.

14. The fungus body as described above consists merely of a loose web of filaments or hyphae produced by the repeated branching of those which arise from germinating spores. This web extends within the diseased spot and afterwards appears on the surface. Each filament is a clear transparent tube filled with colourless protoplasm in which are droplets of oil and other bodies. After attaining a certain development the tips of free branches swell up into roundish or more usually inverted pear-shaped spores. The swelling is cut off from its supporting branch by a cellulose wall and matures while still attached. When ripe, it usually falls off and if it drops into water from rain or dew, germinates rapidly.

15. This it does by the free end pushing out a small colourless papilla which becomes altered and highly refractive to light. The papilla softens into a gelatinous substance which blows out into a bladder through pressure developed within the spore. Into this bladder, formed of a wall little thicker than that of a soap bubble, the contents of the spore stream leaving the spore itself empty. Within the bladder the spore protoplasm soon divides up into a number of small masses which become motile and swim away by the beating of two cilia, rupturing the bladder. These are the zoospores, as many as thirty or forty being sometimes formed from a single spore and, being motile, they serve to disseminate the species. As the spores are very thin (about one-seven hundreth of an inch), very little water is sufficient to submerge them, and then zoospores are produced. When their movement comes to an end, the zoospores themselves germinate by putting out a filament which can penetrate the palm tissues and give rise to a new spot of disease.

16. This last stage, that of infection, has not been followed out in the species under consideration owing to the investigation being made at a distance from working facilities, but it is given from the analogy of other species. Until, however, infection has been obtained by sowing a healthy leaf with the zoospores and finding that their germ filaments can penetrate and kill the tissues, the evidence that the fungus is the real cause of the disease is incomplete. All the probabilities point that way, however, and the fact that it alone is found in the spot in the early stages of disease joined to its parasitic structure is strongly in favor of this view. An organism of this type, too, would account for the slow extension of the disease. Its spores are produced chiefly in the inner layers of the bud and then not often in great quantities, while being comparatively large and requiring to fall into water in order to germinate, a number of conditions have to be favorable to allow of extension to new trees.

17. A second type of spore is found on older spots. This is a sexually produced zoospore, a thick walled body suited to withstand conditions which would kill the more delicate spores above described. On germination this form gives rise to a short mycelium on which spores of the first type are produced.

18. Dissemination may be brought about in several ways. Withering of the head may expose the inner sheaths where most of the spores are produced, or some of the latter may occasionally form on the outer layer especially on the secondary spots which develop from extension from diseased areas within the bud, and in either case they would be carried about by the wind. Once the wet rot which invariably follows as appeared, this mode of spread is not likely to occur as only the second spore form can survive in the putrid mass, and it is questionable if even this can stand it long. Insects might very easily carry infection should they gain access to the spore-bearing mycelium on the surface of the spots. Infection may also be carried by the knives of the toddy-drawers since each tree is climbed every year either to draw toddy or to cut the leaves. In all these cases the danger is lessened by the fact that spore formation occurs usually between the inner layers of the bud and this probably accounts for the slow spread.

19. From the above it can be seen that the disease may be fought in two ways. The formation of spores may be checked by cutting off the bud from the stem as soon as the first leaf turns white. This entails little loss except the cost of labour, for recovery does not appear ever to occur, and the flow of toddy during the remainder of the life of the tree is small. At the same time infection of healthy trees can be guarded against by brushing or spraying the outside of the bud below the expanded leaves with Bordeaux mixture. The area affected is at present small, extension is comparatively slow and it is well worth while endeavouring to stamp out the disease now.

20. The suggestions which I should make for an organised campaign against the disease are as follows. Their carrying out will necessitate the formation of a special staff for the purpose, for it is certain that at first at least, the villagers will be slow to take measures for their own protection. If, however, the results bear out the value of the work, real co-operation may be expected before long. A number of expert palm climbers (such as toddy-drawers) should be selected under the charge of an Agricultural Inspector or some similar official and provided with small axes. They should be instructed to climb all diseased trees, both those in the early stages and those already dead, and to cut off the green tops below the swelling of the leaf sheaths. It is particularly essential that all trees in the early stages should be dealt with and these can be recognised, where the villagers themselves are unable to do so, by the whitening of one of the leaves towards the centre of the head. After cutting off the heads the whole of the tops should be collected into a heap in each village and burnt. In this way, every dead or attacked palm in a selected area should have its power of spreading infection destroyed by burning the diseased parts, and this measure alone, if steadily pursued, is certain to give good results. The infectious matter is confined to the head of the palm and as the tree is doomed once the disease appears and will yield little or no further profit, its removal costs little but the actual expense of labour in cutting it down and burning it.

21. To save healthy trees within the affected districts in places where they are surrounded by large numbers of dead or dying trees is difficult unless the above measures are very thoroughly carried out. But the chances of their infection may be very largely diminished if they are brushed with Bordeaux mixture on the leaf sheaths when the removal of diseased trees commences. Bordeaux mixture is a substance which adheres strongly to the surfaces of plants, and being poisonous to fungus spores it prevents their germination or kills the young germ filaments as soon as they appear. A second gang of toddy drawers should be employed for this work and provided with small vessels containing the mixture and mops of rags for brushing it on to the sheaths. The expanded leaves need not be brushed, but only the leaf sheaths below these. One man should be able to do from 30 to 50 trees in a day and if the work is done at the time that the trees are climbed for cutting the leaves, the cost of the labour should be small. The men employed for removing diseased trees should not be allowed to climb healthy ones as there is some danger of their conveying the infection on their persons or axes. The cost of the materials used cannot be exactly given as it depends on the price at which copper sulphate can be landed in the district and the availability of a supply of good lime in the neighbourhood. A pint would probably be enough to treat one tree and this should not cost more than about one pie.

22. Instructions for preparing Bordeaux mixture are appended. The best time for commencing operations is probably the cold season, as I obtained some indications that the disease is most active at that time. I can provide some trained assistance from my office and can probably arrange to spend some time in the Godavari to superintend the commencement of the work should the Madras Government decide to adopt my recommendations.

Instructions for making Bordeaux Mixture.

23. To prepare 50 gallons of the mixture weigh out 6 lb. copper sulphate, break to powder and dissolve in 25 gallons of cold water by suspending in a piece of gunny sacking in the water. The latter must not be contained in a metal vessel but in a barrel or big earthenware pot. In another vessel weigh out 4 lb. of fresh quick lime. Slake this gradually till it falls to powder and then add water up to 25 gallons. Let cool. When cool add to the copper sulphate solution through a sieve so as to retain any lumps which would clog the sprayer. A thick bluish liquid results which on standing throws down a bluish precipitate leaving the other part of the liquid clear. To test it fit for use add a few drops of ferrocyanide of potassium to a small quantity of the clear liquid in a dish. If a brownish precipitate appears more lime must be added till no precipitate is given on testing. Or a steel knife may be dipped in it and if more lime is necessary a deposit of copper will form on the knife. If none is formed it is ready for use. Stir well before using.

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For annas 8 shown in each of the three sub-columns of columns 23 and 24 of the statements of wholesale prices, for the fortnights ending 30th April and the 15th May 1907, as the price of grass and straw in the Kolar District, read Rs. 4-8-0.

Vide pages 340 and 370 of Part IV of the Gazette.

By Order,

C. S. BALASUNDARAM IYER,

Offg. Secy. to Govt., Gen. & Rev. Depts.